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The Effect of Ultisols Subsoil Combined with Mexican Sunflower (*Tithonia diversifolia*) Compost and Vermicompost on Pre-Nursery Growth of Oil Palm Seedling

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ABSTRACT

The productivity of oil palm is determined by the use of high-quality seedlings that have good growth potential, appearance, and the ability to grow in various environmental conditions. To obtain good oil palm seedlings, attention must be paid to the planting media used. The objective of this research was to determine the appropriate composition of planting media, consisting of Ultisols subsoil, compost, and vermicompost, for oil palm seedlings in the pre-nursery stage. This study was conducted from January to April 2023, used a Completely Randomized Design (CRD) with a single factor consisting of 10 treatments, which are 100% Ultisols subsoil, 80% Ultisols subsoil + 20% mexican sunflower compost, 80% Ultisols subsoil + 20% vermicompost, 60% Ultisols subsoil + 20% mexican sunflower compost + 20% vermicompost, 60% Ultisols subsoil + 10% mexican sunflower compost + 30% vermicompost, 60% Ultisols subsoil + 30% mexican sunflower compost + 10% vermicompost, 60% Ultisols subsoil + 40% mexican sunflower compost 60% Ultisols subsoil + 40% vermicompost, 50% Ultisols subsoil + 50% mexican sunflower compost, 50% Ultisols subsoil + 50% vermicompost. The research results showed that the composition of 60% Ultisols subsoil + 40% vermicompost provided the best growth for oil palm seedlings in the pre-nursery stage, as evidenced by seedling growth parameters such as plant height, number of leaves, leaf area, root volume, root dry weight, crown dry weight, and plant dry weight.

INTRODUCTION

Oil palm (*Elaeis guineensis* Jacq.) is one of the flagship crops for plantation entrepreneurs and plays a significant role in the Indonesian economy. According to data from the Central Statistics Agency (BPS, 2022), the oil palm plantation area in 2020 covered a total of 14,586,597 ha and produced palm oil up to 45,741,835 tons. In 2021, the oil palm plantation area increased to 14,621,693 ha; however, the production yield decreased to 45,121,480 tons. In 2020, the province of Bengkulu had an oil palm plantation area of 318,352 ha and was capable of producing 1,066,171 tons. In 2021, the oil palm plantation area in Bengkulu expanded to 372,822 ha, but the production declined, yielding only 994,583 tons.

The expansion of oil palm plantations will undoubtedly require a large quantity of oil palm seedlings, both for increasing the

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planting area (extensification) and for replanting or replacing unproductive oil palm trees. One of the factors that can enhance the success and productivity of oil palm cultivation is using high-quality seedlings. Quality oil palm seedlings possess strong growth potential, good appearance, and resilience to environmental stress during the transplanting process. Oil palm seedlings are typically cultivated in two stages, namely the pre-nursery and main nursery stages (Fauzi *et al*., 2012). The success of the seedling stage determines whether the oil palm seedlings will meet the desired criteria when transplanted to the field. To achieve high-quality oil palm seedlings, careful attention must be paid to the planting media used (Ariyanti *et al*., 2017).

The commonly used planting medium for oil palm seedlings is the topsoil because topsoil is rich in organic matter. However, its availability is diminishing due to erosion and land use changes, leaving behind only the subsoil (Suherman, 2006). Ultisols subsoil can serve as an alternative planting medium for oil palm seedlings in the pre-nursery stage, as Ultisols are widely distributed in the Bengkulu Province. According to Sembiring *et al*. (2015), Ultisols subsoil is characterized by poor nutrient content and low soil fertility. Ultisols are known for their acidic soil reaction, deep soil profile, low base saturation, and deficiency in essential nutrients such as Ca, Mg, Na, K, and especially P (Prasetyo and Suriadikarta, 2006).

The fertility level of Ultisols subsoil can be improved when its application is accompanied by the addition of organic materials or soil conditioners that can enhance the physical, chemical, and biological properties of the soil (Bahri *et al*., 2017). One of the organic materials that can be turned into compost is Tithonia diversifolia, commonly known as mexican sunflower (Arifiati *et al*., 2017). Mexican sunflower has the potential to serve as a supplement to synthetic fertilizers to support plant growth and production, reduce the uptake of active P, Al, and Fe, and decrease pollutants (Kesuma, 2020). Research conducted by Septian *et al*. (2015) found that mexican sunflower compost contains 3.5% N, 0.37% P, 4.10% K, 0.59% Ca, and 0.27% Mg, and it can reduce Al toxicity while increasing soil pH (Hakim *et al*., 2007). The study by Pratama (2019) showed that the application of mexican sunflower compost at 62.5 g/ polybag can enhance the growth of oil palm seedling roots and canopies, producing the best root-to-canopy ratio. Applying mexican sunflower compost at a dosage of 50 g/ polybag can also promote the height growth of oil palm seedlings during the early nursery stage (Pratama *et al.,* 2019). In addition to mexican sunflower compost, another organic material that can be used to enhance the fertility of Ultisols subsoil is vermicompost.

Vermicompost is a mixture of earthworm castings with residual media or feed in earthworm farming. Vermicompost is an environmentally friendly organic fertilizer that has its advantages compared to other composts (Oktaviani and Ekawati 2023). One of the advantages of using vermicompost fertilizer is its ability to improve soil quality and increase soil pH (Purniasari *et al*., 2019). Vermicompost contains growth-regulating substances such as auxins, cytokinins, and gibberellins, which are beneficial for plant growth and development (Arifah, 2014). Vermicompost can also stimulate the growth of roots, stems, and leaves in oil palm seedlings (Manahan *et al*., 2016). Research by Romadhoni (2022) showed that a planting medium composition of 80% Ultisols subsoil + 20% vermicompost fertilizer the best results in terms of plant height and the number of leaves of oil palm seedlings in the pre-nursery stage at 12 weeks after transplanting. Siregar's study (2017) demonstrated that the application of vermicompost fertilizer to oil palm seedlings in the pre-nursery phase led to good growth in terms of plant height, stem diameter, wet weight, and dry weight, with the best dosage being 90 g/ polybag. According to Rangkuti's research (2018), vermicompost fertilizer resulted in good growth in terms of the height, wet weight, and dry weight of oil palm seedlings in the pre-nursery, with the best dosage being 120 g/polybag in polybags measuring 15 x 25 cm.

MATERIALS AND METHOD

This research was conducted from January to April 2023, at Jl. WR Supratman, Kandang Limun Village, Muara Bangkahulu Sub District, Bengkulu City, at ± 10 m above sea level. This research employed a Completely Randomized Design (CRD) with a single factor involving various treatment levels for the planting media, namely: M_1 (100% Ultisols subsoil), M_2 (80% Ultisols subsoil + 20% mexican sunflower compost), M_3 (80% Ultisols subsoil + 20% vermicompost), M_4 (60% Ultisols subsoil + 20% mexican sunflower compost + 20% vermicompost), M_5 (60% Ultisols subsoil + 10% mexican sunflower compost + 30% vermicompost), M_6 (60% Ultisols subsoil + 30% mexican sunflower compost + 10% vermicompost), M_7 (60% Ultisols subsoil + 40% mexican sunflower compost), M_8 (60% Ultisols subsoil + 40% vermicompost), M_9 (50% Ultisols subsoil + 50% mexican sunflower compost), M_{10} (50% Ultisols subsoil + 50% vermicompost).

The growth parameters of oil palm seedlings observed are as follows: seedling height (cm), stem diameter (mm), number of leaves (pieces), total leaf area (cm²), leaf greenness level (unit), number of stomata, root length (cm), root volume (ml), shoot dry weight (g), root dry weight (g), plant dry weight (g), shoot-to-root dry weight ratio (shoot-root ratio), The observation data were analyzed using Analysis of Variance (ANOVA) with a significance level of 5%. If the analysis of variance results indicate a significant effect, Duncan's Multiple Range Test (DMRT) was performed for correlation analysis between variables.

RESULTS AND DISCUSSION

Results

The planting medium used in the pre-nursery stage of oil palm seedlings was Ultisols subsoil, which had been analyzed prior to the study. The analysis of the Ultisols subsoil, conducted at the Soil Science Laboratory, Faculty of Agriculture, University of Bengkulu, revealed that the soil was acidic with a pH value of 4.98, and the available nutrient content was as follows: organic C content at 2.18% (medium), N at 0.15% (low), P at 4.70 ppm (medium), and K at 0.25 me/100 g (low). The analysis of nutrient content in Mexican sunflower compost showed N at 1.48%, P at 0.87%, K at 2.13%, and organic C at 25.74%. The analysis of nutrient content in vermicompost indicated N at 3.64%, P at 0.89%, K at 1.07%, and organic C at 21.79%.

During the research conducted from January to April, there was rainfall with the following consecutive intensities: 11.33 mm, 14.88 mm, 17.20 mm, and 19.70 mm per month, with average air humidity of 84%, 83%, 83%, and 84%, respectively. The air temperatures were recorded as follows: 26.32° C, 26.75°C, 27.12°C, and 27.39°C, respectively. The optimal rainfall for oil palm seedling cultivation is between 166 mm and 208 mm per month, with average air temperatures ranging from 24°C to 29°C and air humidity between 80% and 90% (BMKG, 2023). Based on the data obtained, the air temperature and humidity meet the growth requirements for oil palm seedlings. However, the rainfall data still fall short of meeting the requirements for oil palm seedling growth, which is why watering 1-2 times a day is necessary.

The visual observations during the research showed continuous growth of the seedlings, including plant height, the number of leaves, leaf area, and stem diameter. Approximately 90% of the planted seedlings began to develop their first leaves at the age of 2 weeks after transplanting (2 WAT). The criteria for normal oil palm seedlings are as follows: at the age of 16 weeks after transplanting (16 WAT), the seedlings should have 4-5 leaves, a height of 21.5 cm, and a stem diameter of 1.2 cm (PPKS 2014). In general, the oil palm seedlings grew well and appeared to be normal. However, at 6 weeks after transplanting (6 WAT), the plants began to be attacked by pests, specifically the *Adoretus* beetle (*Adoretus compressus*). The pest infestation resulted in the leaves of the seedlings being eaten, starting from the base, middle, and tips of the leaves, causing leaf damage. Pest control was carried out by regularly spraying insecticide with the active ingredient *Kalbaril 85%* twice a week in the evening. Weed control in the research shading area was done manually by removing weeds and applying herbicide outside the shaded area.

Based on the analysis of variance results, it is known that the composition of the planting medium has a significant effect on the variables of plant height, stem diameter, total leaf area, the number of leaves, root volume, root dry weight, shoot dry weight, and plant dry weight, while it does not have a significant effect on the variables of leaf greenness level, the number of stomata, root length, and shoot-root ratio (Table 1)

The analysis of variance results indicate that the composition of the planting medium significantly affects the variables of plant height and stem diameter (Table 1). Further tests show that the planting medium composition M8 resulted in the tallest plant height (33.17 cm), which did not significantly differ from the plant heights of M_{10}, M_5, M_3, M_1, M_4, M_2, and M_6, significantly differed from the plant heights of M_9 and M_7 (Table 2). Stem diameter in composition M_{10} yielded the largest stem diameter (12.03 mm), which did not significantly differ from the stem diameters of M_8, M_1, M_3, M_5, M_4, and M_6, significantly differed from the stem diameters of M_9, M_7, and M_2 (Table 2).

The analysis of variance results indicate that the composition of the planting medium significantly affects the variables of the number of leaves and total leaf area (Table 1). The analysis results show that the number of leaves in the planting medium composition M_8 and M_5 resulted in the highest number of leaves (6.53 leaves) which did not significantly differ from the number of leaves M_{10}, M_1, M_3, M_9, M_4, M_6, and M_7, significantly differed from the number of leaves M_2 (Table 2). The medium composition M_8 resulted in

Table 1. Summary of the analysis of variance results on the effect of the composition of ultisols subsoil planting medium, mexican sunflower compost, and vermicompost on the growth of oil palm seedlings in the pre-nursery stage.

Variables	F-calculate	F 5%
Plant Height	4.36*	2.39
Stem Diameter	4.25*	2.39
Number of Leaves	2.70*	2.39
Total Leaf Area	7.50*	2.39
Leaf Greenness	0.47^{ns}	2.39
Number of Stomata	1.18^{ns}	2.39
Root Length	0.96^{ns}	2.39
Root Volume	8.62*	2.39
Root Dry Weight	7.85*	2.39
Shoot Dry Weight	12.28*	2.39
Plant Dry Weight	12.02*	2.39
Shoot Root Ratio^t	0.54^{ns}	2.39

Note: * = significant effect, ns = not significant effect at the 5% significance level.
t = transformed data $\sqrt{(x+0.5)}$

Table 2. The effect of the composition of ultisols subsoil planting medium, mexican sunflower compost, and vermicompost on the growth of oil palm seedlings in the pre-nursery stage

Treatment	Variables							
	Plant height (cm)		Stem diameter (mm)		Number of leaves		Total leaf area (cm²)	
M_1	28.19	bc	11.94	ab	6.20	abc	293.12	bcd
M_2	27.68	bc	10.03	cd	5.33	c	241.62	de
M_3	29.53	ab	11.62	ab	6.13	abc	313.59	bcd
M_4	28.17	bc	10.44	bcd	5.53	bc	262.55	cde
M_5	30.04	ab	11.45	abc	6.53	a	328.94	bc
M_6	26.90	bc	10.43	bcd	5.53	bc	255.57	de
M_7	25.36	c	9.67	d	5.46	bc	214.27	e
M_8	33.17	a	11.95	ab	6.53	a	399.96	a
M_9	25.22	c	9.57	d	5.60	abc	220.23	e
M_{10}	30.66	ab	12.03	a	6.33	ab	356.58	ab

Note : The numbers followed by the same letters in the same column do not significantly differ in the DMRT at a 5% significance level. M_1 (100% SU), M_2 (80% SU+ 20% mexican sunflower compost), M_3 (80% SU + 20% vermicompost), M_4 (60% SU+ 20% mexican sunflower compost + 20% vermicompost), M_5 (60% SU+ 10% mexican sunflower compost + 30% vermicompost), M_6 (60% SU+ 30% mexican sunflower compost + 10% vermicompost), M_7 (60% SU + 40% mexican sunflower compost), M_8(60% SU + 40 % vermicompost), M_9 (50% SU + 50% mexican sunflower compost), M_{10} (50% SU + 50 % vermicompost).

Table 3. The effect of the composition of ultisols subsoil planting medium, mexican sunflower compost, and vermicompost on the growth of oil palm seedlings in the pre-nursery stage

Treatment	Variables							
	Root volume (ml)		Root dry weight (g)		Shoot dry weight (g)		Plant dry weight (g)	
M_1	5.30	bc	1.24	bc	2.73	c	3.97	c
M_2	4.20	c	0.94	c	1.92	c	2.87	c
M_3	7.40	ab	1.74	ab	4.21	b	5.95	b
M_4	4.03	c	0.86	c	2.25	c	3.11	c
M_5	8.13	ab	1.84	ab	4.48	b	6.32	b
M_6	2.56	c	0.62	c	1.49	c	2.11	c
M_7	2.96	c	0.78	c	1.43	c	2.21	c
M_8	10.2	a	2.33	a	6.21	a	8.54	a
M_9	2.93	c	0.71	c	1.53	c	2.24	c
M_{10}	8.86	a	2.05	a	4.91	ab	6.96	ab

Note : The numbers followed by the same letters in the same column do not significantly differ in the DMRT at a 5% significance level

the widest leaf area of (399.96 cm^2) which did not significantly differ from the leaf area in M_{10}, M_5 , M_3, M_1 and M_4, significantly differed from the leaf area in M_7, M_9, M_2 , and M_6 .

The analysis of variance results indicate that the medium composition significantly influences the variables of root volume, dry weight of roots, dry weight of canopy, and dry weight of the plant. Medium composition M_8 resulted in the highest root volume of (10.2 ml), which did not significantly differ from the root volume in M_{10}, M_5 , M_3 and M_1 significantly differed from the root volume in M_6, M_9 , M_7, M_4 and M_2. Composition M_8 resulted in the heaviest root dry weight. (2.33 g), which did not significantly differ from the dry weight of roots in M_{10}, M_5, M_3, and $M_,$ significantly differed from the dry weight of roots in M_6 , M_9, M_7, M_4 and M_2 (Table 3).

Composition M_8 resulted in the heaviest shoot dry weight (6.21 g), which did not significantly differ from the shoot dry weight of M_{10}, M_5 and M_3 significantly differed from the shoot dry weight of M_7, M_6 , M_9, M_2, M_4 and M_1 . Composition M_8 also produced the heaviest plant dry weight (8.54 g) which did not significantly differ from the plant dry weight of M_{10}, M_5, and M_3, significantly differed from the plant dry weight of M_6 , M_7, M_9, M_2, M_4 and M_1 (Table 3).

Table 4. The effect of the composition of ultisols subsoil planting medium, mexican sunflower compost, and vermicompost on the growth of oil palm seedlings in the pre-nursery stage

Treat-ment	Variables			
	Leaf green -ness (unit)	Number of stomata	Root length (cm)	Shoot root ratio[t]
M_1	56.33	16	28.43	1.66
M_2	51.40	16	31.60	1.65
M_3	55.34	16	36.40	1.72
M_4	54.74	19	19.86	1.75
M_5	54.77	16	32.96	1.73
M_6	55.61	14	25.70	1.86
M_7	52.60	15	24.96	1.56
M_8	56.66	15	28.83	1.76
M_9	54.21	16	23.90	1.61
M_{10}	55.56	15	30.36	1.70

The results of the variance analysis indicate that the planting media composition has no significant effect on the variables of leaf greenness level, number of stomata, root length, and shoot root ratio. The planting media composition yielded leaf greenness level variable results ranging from 51.40 units to 56.66 units, while the number of stomata variable in the planting media composition yielded results ranging from 14 to 18. In terms of root length, the planting media composition produced results ranging from 19.86 cm to 36.40 cm, and the shoot root ratio variable had results ranging from 1.56 to 1.86 (Table 4).

Discussion

The planting media composition with 60% subsoil Ultisols + 40% vermicompost resulted in the best vegetative growth in pre-nursery oil palm seedlings, with no significant difference compared to the planting media composition of 50% subsoil Ultisols + 50% vermicompost. This indicates that the application of vermicompost to subsoil Ultisols can improve soil fertility, thus enabling optimal growth of oil palm seedlings. The analysis results show that vermicompost contain relatively high nutrient levels, namely N 3.64%, P 0.89%, K 1.07%, and C-organic 21.79%. The high nutrient content in vermicompost can enhance metabolic processes, facilitating the formation of amino acids and proteins for the creation of new cells, ultimately promoting the vegetative growth of oil palm seedlings. Besides contributing nutrients, the fine and crumbly nature of vermicompost can also enhance water absorption and retention in the soil (Romadhoni, 2022).

The factor that significantly influences the activity of vegetative growth in plants such as enlargement, division, and cell differentiation is the availability of nitrogen (N) for the plants. Lakitan (2000) explained that nitrogen can stimulate growth, especially the increase in leaves, which results in broad leaf blades with a high chlorophyll content, allowing plants to produce assimilates in sufficient quantities to support vegetative growth (Wijaya, 2008). The research findings of Amri *et al*. (2018) also indicate that nitrogen and phosphorus nutrients play a role in forming new cells and are essential components in the formation of organic compounds in plants, significantly affecting plant growth.

The composition of subsoil Ultisols planting media with the addition of mexican sunflower compost at 20%, 40%, and 50% resulted in a relatively slow growth response of oil palm seedlings during the vegetative phase. This is believed to be closely related to the availability of nutrients in the planting media. Based on the analysis results, the nutrient content available in mexican sunflower compost is N 1.48%, P 0.87%, and K 2.13%. The analysis shows that the nutrient content of N in mexican sunflower compost is not as abundant as in vermicompost fertilizer, thus it is not yet capable of providing better vegetative growth in oil palm seedlings. In addition to supplying nutrients to plants, the proper application of mexican sunflower compost is also beneficial for the planting media. However, mexican sunflower compost also has a drawback in that it can form compounds with negative effects, which are allelopathic and can inhibit germination and growth. Excessive application can leadapr to nutrient imbalances in the soil (Lestari, 2016). From the perspective of vegetative growth, if the composition of mexican sunflower compost is increased, it will result in relatively slow vegetative growth of oil palm seedlings. Factors influencing allelopathic activities in leaves include microorganism activity, soil absorption capacity for growth-inhibiting substances, and decomposition time (Kurniansyah, 2010).

The planting media composition with 60% subsoil Ultisols and 40% vermicompost fertilizer application resulted in the best growth in terms of root volume, root dry weight, canopy dry weight, and plant dry weight. This is due to the addition of organic matter, namely vermicompost fertilizer, which plays a role in providing nutrients to the media. Additionally, it also aids in retaining water in the media and improving soil structure, thereby facilitating the development of plant roots and nutrient absorption. This aligns with the nutrient content found in vermicompost fertilizer, which includes 3.64% N, 0.89% P, 1.07% K, and 21.79% organic carbon. Hidayat *et al*. (2014) stated that healthy plant roots influence the photosynthesis process, and the availability of nutrients for plants can enhance plant growth. Organic matter can serve as a good planting medium that maximizes nutrient absorption and eases nutrient uptake by the roots..

Phosphorus (P) nutrient plays a crucial role in stimulating root growth and developing the root system. Nasution *et al*. (2014) stated that plants require phosphorus nutrient to stimulate root growth and development, resulting in heavier root mass. Moreover, the presence of growth-stimulating substances (auxins, gibberellins, and cytokinins) contained in kascing fertilizer is believed to influence the plant's ability to absorb nutrients (Saryanto and Sopandi, 2021). The indicator that determines whether a plant is healthy or not is closely related to nutrient uptake availability (Sitorus *et al*., 2014). When nutrient uptake is increased, plant metabolism improves. A better metabolic process affects plant dry weight. Lakitan (2000) also mentioned that an increased amount of nutrients that plants can absorb indirectly enhances the photosynthesis process, resulting in more photosynthate production. The photosynthate production can, in turn, increase plant dry weight, which reflects the plant's nutritional status or its ability to absorb nutrients.

The correlation analysis results show that the dry weight of the plant is significantly and positively correlated with the plant height with a value of (r = 0.711), stem diameter (r = 0.617), leaf count (r = 0.632), total leaf area (r = 0.796), root volume (r = 0.971), root dry weight (r = 0.970), and shoot dry weight (r = 0.996) (Table 5). The strong positive relationships occur because an increase in plant height affects the growth of the stem diameter of oil palm seedlings. An increase in the number of leaves formed on oil palm seedlings will increase the total leaf area value. This indicates that the more leaves there are, the more there will be an increase in the leaf area of oil palm seedlings. With an increasing number of leaves produced by the plant, more photosynthate will be generated by the leaves. A higher rate of photosynthesis results in higher photosynthate production, which is used for the growth and development of oil palm seedlings to produce plant biomass. An increase in biomass can stimulate root development and other organs, allowing the plant to absorb more nutrients from water, and photosynthesis activity will increase, leading to an increase in plant dry weight (Rahmah, 2014). In addition to nutrient availability, dry weight is also influenced by the plant's ability to absorb water from the growing medium. A good growing medium has good soil aeration, making it easier for plant roots to grow and improving root respiration (Surya *et al*., 2017).

CONCLUSION

The composition of the growing medium, 60% subsoil Ultisols + 40% vermicompost fertilizer, resulted in the best growth of oil palm seedlings in the pre-nursery stage, as evidenced by the parameters of plant height, stem diameter, leaf count, total leaf area, root volume, root dry weight, canopy dry weight, and plant dry weight.

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Table 5. Results of correlation analysis on all variables

	PH	SD	NL	TLA	LGL	NS	RL	RV	RDW	SDW	SRR
SD	0.72*										
NL	0.62*	0.75*									
TLA	0.92*	0.79*	0.73*								
LGL	0.08	0.29	0.27	0.25							
NS	0.13	-0.12	0.11	0.06	0.07						
RL	0.35	0.19	0.06	0.27	-0.21	-0.04					
RV	0.72*	0.66*	0.65*	0.80*	0.25	0.05	0.36				
RDW	0.68*	0.65*	0.65*	0.76*	0.24	0.05	0.34	0.98*			
SDW	0.71*	0.60*	0.61*	0.80*	0.24	0.01	0.30	0.95*	0.94*		
SRR	0.17	0.11	0.11	0.22	-0.12	-0.22	-0.10	-0.08	-0.15	0.13	
PDW	0.71*	0.62*	0.63*	0.80*	0.24	0.02	0.32	0.97*	0.97*	0.99*	0.05

Note: * correlated significantly, plant height (PH), stem diameter (SD), number of leaves (NL), total leaf area (TLA), leaf greenness level (LGL), number of stomata (NS), root length (RL), root volume (RV), root dry weight (RDW), shoot dry weight (SDW), plant dry weight (PDW), shoot root ratio (SRR)

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